SECTION 01781

COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The provisions of the Contract Documents apply to the work of this section.

1.2 DESCRIPTION

A. Commissioning; Commissioning, is a systematic process of ensuring that all building systems perform interactively according to the design intent and the owner's operational needs. This is achieved by beginning in the design phase and documenting design intent and continuing through construction, acceptance and the warranty period with actual verification of performance. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing and balancing, performance testing and training.

B. Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents:

1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and mat they receive adequate operational checkout by installing contractors.

2. Verify and document proper performance of equipment and systems.

3. Verify that O&M documentation left on site is complete.

4. Verify that the Owner's operating personnel are adequately trained.

C. The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.

D. Abbreviations. The following are common abbreviations used in the Project Manual and in the Commissioning Plan.

A/E-	Architect and design engineers	FT-	Functional performance test
CA-	Commissioning authority	GC-	General contractor (prime)
CC	Controls contractor	MC-	Mechanical contractor
Cx-	Commissioning	PC-	Prefunctional checklist
Cx Plan-	Commissioning Plan document	PM-	Project manager (of the Owner)
EC-	Electrical contractor	Subs-	Subcontractors to General
		TAB-	Test and balance contractor

1.3 COORDINATION

A. Commissioning Team: The members of the commissioning team consist of the Commissioning authority (CA), the Project Manager (PM), the General Contractor (GC or Contractor), the Architect and design engineers (particularly the mechanical engineer), the Mechanical Contractor (MC), the Electrical Contractor (EC), the TAB representative, the Controls Contractor (CC), any other installing subcontractors or suppliers of equipment. If known, the Owner's building or plant operator/engineer is also a member of the commissioning team.

B. Management: The CA directs and coordinates the commissioning activities and reports to the A/E and the Owner. All members work together to fulfill their contracted responsibilities and meet the objectives of the Contract Documents.

C. Scheduling:

1. The CA will work with the PM and GC according to established protocols to schedule the commissioning activities. The CA will provide sufficient notice to the PM and GC for scheduling commissioning activities. The GC will integrate all commissioning activities into the master schedule. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process.

2. The CA will provide the initial schedule of primary commissioning events at the commissioning scoping meeting. The Commissioning Plan—Construction Phase provides a format for this schedule. As construction progresses more detailed schedules are developed by the CA. The Commissioning Plan also provides a format for detailed schedules.

1.4 COMMISSIONING PROCESS

A. Commissioning Specifications: The Commissioning Specifications are binding on the Contractor. The commissioning specifications provide guidance in the execution of the commissioning process. After the initial commissioning scoping meeting the CA will issue an initial Commissioning Plan that will continue to evolve and expand in detail as the project progresses.

B. Commissioning Process: The following narrative provides a brief overview of the typical commissioning tasks during construction and the general order in which they occur.

1. Commissioning during construction begins with a scoping meeting conducted by the CA where the commissioning process is reviewed with the commissioning team members.

2. Additional meetings will be required throughout construction, scheduled by the CA with necessary parties attending, to plan, scope, coordinate, schedule future activities and resolve problems.

3. Equipment documentation is submitted to the CA during normal submittals, including detailed start-up procedures.

4. The CA works with the Subs in developing startup plans and startup documentation formats, including providing the Subs with prefunctional checklists to be completed, during the startup process.

5. In general, the checkout and performance verification proceeds from simple to complex; from component level to equipment to systems and intersystem levels with prefunctional checklists being completed before functional testing.

6. The Subs, under their own direction, execute and document the prefunctional checklists and perform startup and initial checkout. The CA documents that the checklists and startup were completed according to the approved plans. This may include the CA witnessing start-up of selected equipment.

7. The CA develops specific equipment and system functional performance test procedures. The Subs review the procedures.

8. The procedures are executed by the Subs, under the direction of, and documented by the CA.

9. Items of non-compliance in material, installation or setup are corrected at the Sub's expense and the system retested.

10. The CA reviews the O&M documentation for completeness.

11. Commissioning is completed before Substantial Completion.

12. The CA reviews, pre-approves and coordinates the training provided by the Subs and verifies that it was completed.

13. Deferred testing is conducted, as specified or required.

1.5 RESPONSIBILITIES

A. The responsibilities of various parties in the commissioning process are provided in this section. The responsibilities of the mechanical contractor, TAB and controls contractor are in Division 15 and those of the electrical contractor in Division 16.

B. The services for the Project Manager, Architect, HVAC mechanical and electrical designers/engineers are not provided for in this contract. Their responsibilities are listed here to clarify the commissioning process.

C. All Parties: Attend commissioning scoping meeting and additional meetings, as necessary.

D. Architect:

1. Construction and Acceptance Phase:

a. Manage the CA contract.

b. Attend the commissioning scoping meeting and selected commissioning

team meetings.

c. Perform normal submittal review, construction observation, as-built drawing preparation, O&M manual preparation, etc., as contracted.

d. Provide any design narrative documentation requested by the CA.

e. Coordinate resolution of system deficiencies identified during commissioning, according to the contract documents.

f. Prepare and submit final as-built design intent documentation for inclusion in the O&M manuals. Review and approve the O&M manuals.

2. Warranty Period: Coordinate resolution of design non-conformance and design deficiencies identified during warranty-period commissioning.

E. Mechanical and Electrical Engineers:

1. Construction and Acceptance Phase:

a. Perform normal submittal review, construction observation, as-built drawing preparation, etc., as contracted. One site observation should be completed just prior to system startup.

b. Provide any design narrative and sequences documentation requested by the CA. The designers shall assist (along with the contractors) in clarifying the operation and control of commissioned equipment in areas where (he specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

c. Attend commissioning scoping meetings and other selected commissioning team meetings.

d. Participate in the resolution of system deficiencies identified during commissioning, according to the contract documents.

e. Prepare and submit the final as-built design intent and operating parameters documentation for inclusion in the O&M manuals. Review and approve the O&M manuals.

f. From the Contractor's red-line drawings, edit and update one-line diagrams developed as part of the design narrative documentation and those provided by the vendor as shop drawings for the chilled and hot water, condenser water, domestic water, steam and condensate systems; supply, return and exhaust air systems and emergency power system.

g. Provide a presentation at one of the training sessions for the Owner's personnel.

h. Review the prefunctional checklists for major pieces of equipment for

sufficiency prior to their use.

i. Review the functional test procedure forms for major pieces of equipment for sufficiency prior to their use.

j. Witness testing of selected pieces of equipment and systems.

2. Warranty Period: Participate in the resolution of non-compliance, non-conformance and design deficiencies identified during commissioning during warranty-period commissioning.

F. Commissioning Authority (CA): The CA is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management. The CA may assist with problem-solving non-conformance or deficiencies, but ultimately that responsibility resides with the general contractor and the A/E. The primary role of the CA is to develop and coordinate the execution of a testing plan, observe and document performance—that systems are functioning in accordance with the documented design intent and in accordance with the Contract Documents. The Contractors will provide all tools or the use of tools to start, check-out and functionally test equipment and systems, except for specified testing with portable data-loggers, which shall be supplied and installed by the CA.

1. Construction and Acceptance Phase:

a. Coordinates and directs the commissioning activities in a logical, sequential and efficient manner using consistent protocols and forms, centralized documentation, clear and regular communications and consultations with all necessary parties, frequently updated timelines and schedules and technical expertise.

b. Coordinate the commissioning work and, with the GC and PM, ensure that commissioning activities are being scheduled into the master schedule.

c. Plan and conduct a commissioning scoping meeting and other commissioning meetings.

d. Request and review additional information required to perform commissioning tasks, including O&M materials, contractor start-up and checkout procedures.

e. Before startup, gather and review the current control sequences and interlocks and work with contractors and design engineers until sufficient clarity has been obtained, in writing, to be able to write detailed testing procedures.

f. Review and approve normal Contractor submittals applicable to systems being commissioned for compliance with commissioning needs, concurrent with the A/E reviews.

g. Write and distribute prefunctional tests and checklists.

h. Develop an enhanced start-up and initial systems checkout plan with Subs.

i. Perform site visits, as necessary, to observe component and system installations. Attend selected planning and job-site meetings to obtain information on construction progress. Review construction meeting minutes for revisions/substitutions relating to the commissioning process. Assist in resolving any discrepancies.

j. Witness all or part of the HVAC piping test and flushing procedure, sufficient to be confident that proper procedures were followed. Document this testing and include the documentation in O&M manuals. Notify owners project manager of any deficiencies in results or procedures.

k. Witness all or part of any ductwork testing and cleaning procedures, sufficient to be confident that proper procedures were followed. Document this testing and include the documentation in O&M manuals. Notify owner's project manager of any deficiencies in results or procedures.

l. Approve prefunctional tests and checklist completion by reviewing prefunctional checklist reports and by selected site observation and spot checking.

m. Approve systems startup by reviewing start-up reports and by selected site observation.

n. Review TAB execution plan.

o. Oversee sufficient functional testing of the control system and approve it to be used for TAB, before TAB is executed.

p. Approve air and water systems balancing by spot testing, by reviewing completed reports and by selected site observation.

q. With necessary assistance and review from installing contractors, write the functional performance test procedures for equipment and systems. This may include energy management control system trending, stand-alone datalogger monitoring or manual functional testing. Submit to PM for review, and for approval if required.

r. Analyze any functional performance trend logs and monitoring data to verify performance.

s. Coordinate, witness and approve manual functional performance tests performed by installing contractors. Coordinate retesting as necessary until satisfactory performance is achieved. Perform actual functional testing without contractors on equipment so specified in Sections 15030.

t. Maintain a master deficiency and resolution log and a separate testing record. Provide the PM with written progress reports and test results with recommended actions.

u. Witness performance testing of smoke control systems by others and all other owner contracted tests or tests by manufacturer's personnel over which the CA may not have direct control. Document these tests and include this documentation in Commissioning Record in O&M manuals.

v. Review equipment warranties to ensure that the Owner's responsibilities are clearly defined.

w. Oversee and approve the training of the Owner's operating personnel.

x. Compile and maintain a commissioning record and building systems book(s).

y. Review and approve the preparation of the O&M manuals.

z. Provide a final commissioning report (as described in this section).

aa. Optional: Prepare a standard trend logging package of primary parameters that will provide the operations staff clear indications of system function in order to identify proper system operation and trouble shoot problems. The CA shall also provide any needed information on interpreting the trends.

2. Warranty Period:

a. Coordinate and supervise required seasonal or deferred testing and deficiency corrections.

b. Return to the site at 10 months into the 12 month warranty period and review with facility staff the current building operation and the condition of outstanding issues related to the original and seasonal commissioning. Also interview facility staff and identify problems or concerns they have operating the building as originally intended. Make suggestions for improvements and for recording these changes in the O&M manuals. Identify areas that may come under warranty or under the original construction contract. Assist facility staff in developing reports, documents and requests for services to remedy outstanding problems.

c. Optional: Assist in the development of a preventative maintenance plan, a detailed operating plan or an energy and resource management plan or as-built documentation.

G. Owner's Project Manager (PM):

1. Construction and Acceptance Phase:

a. Manage the contract of the A/E and of the GC.

b. Arrange for facility operating and maintenance personnel to attend various field commissioning activities and field training sessions according to the Commissioning Plan—Construction Phase.

c. Provide final approval for the completion of the commissioning work.

2. Warranty Period: Ensure that any seasonal or deferred testing and any deficiency issues are addressed.

H. General Contractor (GC):

1. Construction and Acceptance Phase:

a. Facilitate the coordination of the commissioning work by the CA, and with the GC and CA ensure that commissioning activities are being scheduled into the master schedule.

b. Include the cost of commissioning in the total contract price.

c. Furnish a copy of all construction documents, addenda, change orders and approved submittals and shop drawings related to commissioned equipment to the CA.

d. In each purchase order or subcontract written, include requirements for submittal data, O&M data, commissioning tasks and training.

e. Ensure that all Subs execute their commissioning responsibilities according to the Contract Documents and schedule.

f. A representative shall attend a commissioning scoping meeting and other necessary meetings scheduled by the CA to facilitate the Cx process.

g. Coordinate the training of owner personnel.

h. Prepare O&M manuals, according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.

2. Warranty Period:

a. Ensure that Subs execute seasonal or deferred functional performance testing, witnessed by the CA, according to the specifications.

b. Ensure that Subs correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

I. Equipment Suppliers:

1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in force.

2. Assist in equipment testing per agreements with Subs.

3. Include all special tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment according to these Contract Documents in the base bid price to the Contractor, except for stand-alone datalogging equipment that may be used by the CA.

4. Through the contractors they supply products to, analyze specified products and verify that the designer has specified the newest most updated equipment reasonable for this project's scope and budget.

5. Provide information requested by CA regarding equipment sequence of operation and testing procedures.

6. Review test procedures for equipment installed by factory representatives.

1.6 DEFINITIONS

Acceptance Phase - phase of construction after startup and initial checkout when functional performance tests, O&M documentation review and training occurs.

Approval - acceptance that a piece of equipment or system has been properly installed and is functioning in the tested modes according to the Contract Documents.

Architect/Engineer (A/E) - the prime consultant (Architect) and sub-consultants who comprise the design team, generally the HVAC mechanical designer/engineer and the electrical designer/engineer.

Basis of Design - The basis of design is the documentation of the primary thought processes and assumptions behind design decisions that were made to meet the design intent. The basis of design describes the systems, components, conditions and methods chosen to meet the intent. Some reiterating of the design intent may be included.

Commissioning Authority (CA) - an independent agent, the CA directs and coordinates the day-to-day commissioning activities. The CA does not take an oversight role.

Commissioning Plan - an overall plan that provides the structure, schedule and coordination planning for the commissioning process.

Contract Documents - the documents binding on parties involved in the construction of this project (drawings, specifications, change orders, amendments, contracts, Cx Plan, etc.).

Contractor - the general contractor or authorized representative.

Control system - the central building energy management control system.

Datalogging - monitoring flows, currents, status, pressures, etc. of equipment using stand-alone dataloggers separate from the control system.

Deferred Functional Tests - FTs that are performed later, after substantial completion, due to partial occupancy, equipment, seasonal requirements, design or other site conditions that disallow the test from being performed.

Deficiency - a condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents (that is, does not perform properly or is not complying with the design intent).

Design Intent - a dynamic document that provides the explanation of the ideas, concepts and criteria that are considered to be very important to the owner. It is initially the outcome of the programming and conceptual design phases.

Design Narrative or Design Documentation - sections of either the Design Intent or Basis of Design.
Factory Testing - testing of equipment on-site or at the factory by factory personnel with an Owner's representative present.

Functional Performance Test (FT) - test of the dynamic function and operation of equipment and systems using manual (direct observation) or monitoring methods. Functional testing is the dynamic testing of systems (rather than just components) under full operation (e.g., the chiller pump is tested interactively with the chiller functions to see if the pump ramps up and down to maintain the differential pressure setpoint). Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all the control system's sequences of operation and components are verified to be responding as the sequences state. Traditional air or water test and balancing (TAB) is not functional testing, in the commissioning sense of the word. TAB's primary work is setting up the system flows and pressures as specified, while functional testing is verifying that which has already been set up. The commissioning authority develops the functional test procedures in a sequential written form, coordinates, oversees and documents the actual testing, which is usually performed by the installing contractor or vendor. FTs are performed after prefunctional checklists and startup are complete.

General Contractor (GC) - the prime contractor for this project. Generally refers to all the GC's subcontractors as well. Also referred to as the Contractor, in some contexts.

Indirect Indicators - indicators of a response or condition, such as a reading from a control system screen reporting a damper to be 100% closed.

Manual Test - using hand-held instruments, immediate control system readouts or direct observation to verify performance (contrasted to analyzing monitored data taken over time to make the "observation").

Monitoring - the recording of parameters (flow, current, status, pressure, etc.) of equipment operation using dataloggers or the trending capabilities of control systems.

Non-Compliance - see Deficiency.

Non-Conformance - see Deficiency.

Over-written Value - writing over a sensor value in the control system to see the response of a system (e.g., changing the outside air temperature value from 50F to 75F to verify economizer operation). See also "Simulated Signal."

Owner-Contracted Tests - tests paid for by the Owner outside the GC's contract and for which the CA does not oversee. These tests will not be repeated during functional tests if properly documented.

Phased Commissioning - commissioning that is completed in phases (by floors, for example) due to the size of the structure or other scheduling issues, in order minimize the total construction time.

Prefunctional Checklist (PC) - a list of items to inspect and elementary component tests to conduct to verify proper installation of equipment, provided by the CA to the Sub. Prefunctional checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension, oil levels OK, labels affixed, gages in place, sensors calibrated, etc.). However, some prefunctional checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three phase pump motor of a chiller system). The word prefunctional refers to before functional testing. Prefunctional checklists augment and are combined with the manufacturer's start-up checklist. Even without a commissioning process, contractors typically perform some, if not many, of the prefunctional checklist items a commissioning authority will recommend. However, few contractors document in writing the execution of these checklist items. Therefore, for most equipment, the contractors execute the checklists on their own. The commissioning authority only requires
that the procedures be documented in writing, and does not witness much of the prefunctional checklisting, except for larger or more critical pieces of equipment,

Project Manager (PM) - the contracting and managing authority for the Owner over the design and/or construction of the project, a staff position.

Sampling. - functionally testing only a fraction of the total number of identical or near identical pieces of equipment.

Seasonal Performance Tests - FT that are deferred until the system(s) will experience conditions closer to their design conditions.

Simulated Condition - condition that is created for the purpose of testing the response of a system (e.g., applying a hair blower to a space sensor to see the response in a VAV box).

Simulated Signal - disconnecting a sensor and using a signal generator to send an amperage, resistance or pressure to the transducer and DDC system to simulate a sensor value.

Specifications - the construction specifications of the Contract Documents.
Startup - the initial starting or activating of dynamic equipment, including executing prefunctional checklists.

Subs - the subcontractors to the GC who provide and install building components and systems.

Test Procedures - the step-by-step process which must be executed to fulfill the test requirements. The test procedures are developed by the CA.

Test Requirements - requirements specifying what modes and functions shall be tested. The test requirements are not the detailed test procedures. The test requirements are specified in the Contract Documents.

Trending - monitoring using the building control system. Vendor - supplier of equipment.

Warranty Period - warranty period for entire project, including equipment components. Warranty begins at Substantial Completion and extends for at least one year, unless specifically noted otherwise in the Contract Documents and accepted submittals.

1.7 SYSTEMS TO BE COMMISSIONED

A. The following checked systems will be commissioned in this project.

Equipment and System	Functional Test Requirements Specified In:	Equipment and System	Functional Test Requirements Specified In:
HVAC System	15950	_Equipment vibration control	15950
_Chillers	15950		
_Pumps	15950		
_Boilers	15950		
_Piping systems	15950		
_Ductwork	15950		
_Variable frequency drives	15950		
_Air handlers	15950	Other	
_Terminal units (air)	15950	_Service water heaters	15950
_Unit heaters	15950		
_Testing, Adjusting and Balancing work	15950		
_Chemical treatment systems	15950		
_HVAC control system	15950		
_Fire and smoke dampers	15950		
_Indoor air quality [1]	15950		

[1] Indoor air quality (IAQ) commissioning does not ensure that indoor air quality will be adequate or without deficiency at building turnover or during occupancy, unless the Owner has specifically specified that actual air quality testing is performed. Commissioning indoor air quality entails performing tasks that minimize the potential for IAQ problems, but it does not eliminate their possibility.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division contractor for the equipment being tested. For example, the mechanical contractor of Division 15 shall ultimately be responsible for all standard testing equipment for the HVAC system and controls system in Division 15, except for equipment specific to and used by TAB in their commissioning responsibilities. Two-way radios shall be provided by the General Contractor.

B. Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and left on site, except for stand-alone datalogging equipment that may be used by the CA.

C. Datalogging equipment and software required to test equipment will be provided by the CA, but shall not become the property of the Owner.

D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply:

1. Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F.

2. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

3. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

E. Additional equipment may be required to simulate required test conditions, as specified herein.

PART 3 – EXECUTION

3.1 MEETINGS

A. Scoping Meeting: Within 60-90 days of commencement of construction, the CA will schedule, plan and conduct a commissioning scoping meeting with the entire commissioning team in attendance. Meeting minutes will be distributed to all parties by the CA. Information gathered from this meeting will allow the CA to prepare the Commissioning Plan to which will be distributed to all parties.

B. Miscellaneous Meetings: Other meetings will be planned and conducted by the CA as construction progresses. These meetings will cover coordination, deficiency resolution and planning issues with particular Subs. The CA will plan these meetings and will minimize unnecessary time being spent by Subs. These meetings may be held monthly, until the final three (3) months of construction when they may be held as frequently as one per week.

3.2 REPORTING

A. The CA will provide regular reports to the PM, with increasing frequency as construction and commissioning progresses. Standard forms are provided and referenced in the Commissioning Plan.

B. The CA will regularly communicate with all members of the commissioning team, keeping them apprised of commissioning progress and scheduling changes through memos, progress reports, etc.

C. Testing or review approvals and non-conformance and deficiency reports are made regularly with the review and testing as described in later sections.

D. A final summary report (about four to six pages, not including backup documentation) by the CA will be provided to the PM, focusing on evaluating commissioning process issues and identifying areas where the process could be improved. All acquired documentation, logs, minutes, reports, deficiency lists, communications, findings, unresolved issues, etc., will be compiled in appendices and provided with the summary report. Prefunctional checklists, functional tests and monitoring reports will not be part of the final report, but will be stored in the Commissioning Record in the O&M manuals.

3.3 SUBMITTALS

A. The CA will provide appropriate contractors with a specific request for the type of submittal documentation the CA requires to facilitate the commissioning work. These requests will be integrated into the normal submittal process and protocol of the construction team. At minimum, the request will include the manufacturer and model number, the manufacturer's printed installation and detailed start-up procedures, full sequences of operation, O&M data, performance data, any performance test procedures, control drawings and details of owner contracted tests. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning authority. All documentation requested by the CA will be included by the Subs in their O&M manual contributions.

B. The Commissioning Authority will review and approve submittals related to the commissioned equipment for conformance to the Contract Documents as it relates to the commissioning process, to the functional performance of the equipment and adequacy for developing test procedures. This review is intended primarily to aid in the development of functional testing procedures and only secondarily to verify compliance with equipment specifications. The Commissioning authority will notify the A/E, of items missing or areas that are not in conformance with Contract Documents and which require resubmission.

C. The CA may request additional design narrative from the A/E and Controls Contractor, depending on the completeness of the design intent documentation and sequences provided with the Specifications.

D. These submittals to the CA do not constitute compliance for O&M manual documentation. The O&M manuals are the responsibility of the Contractor, though the CA will review and approve them.

3.4 START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

A. The following procedures apply to all equipment to be commissioned. Some systems that are not comprised so much of actual dynamic machinery, e.g., electrical system power quality, may have very simplified PCs and startup.

B. General: Prefunctional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.

C. Start-up and Initial Checkout Plan: The CA shall assist the commissioning team members responsible for startup of any equipment in developing detailed start-up plans for all equipment The primary role of the CA in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures has been completed. Parties responsible for prefunctional checklists and startup are identified in the commissioning scoping meeting and in the checklist forms. Parties responsible for executing functional performance tests are identified in the testing requirements in Divisions 15 and 16.

1. The CA adapts, if necessary, the representative prefunctional checklists and procedures. These checklists indicate required procedures to be executed as part of startup and initial checkout of the systems and the party responsible for their execution.

2. These checklists and tests are provided by the CA to the Contractor. The Contractor determines which trade is responsible for executing and documenting each of the line item tasks and notes that trade on the form. Each form will have more than one trade responsible for its execution.

3. The subcontractor responsible for the purchase of the equipment develops the full start-up plan by combining (or adding to) the CA's checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.

4. The full start-up plan could consist of something as simple as:

a. The CA's prefunctional checklists.

b. The manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end.

c. The manufacturer's normally used field checkout sheets.

5. The subcontractor submits the full startup plan to the CA for review and approval.

6. The CA reviews and approves the procedures and the format for documenting them, noting any procedures that need to be added.

7. The full start-up procedures and the approval form may be provided to the CM for review and approval, depending on management protocol.

D. Sensor and Actuator Calibration: All field-installed temperature, relative humidity, CO, CO_2 and pressure sensors and gages, and all actuators (dampers and valves) on all equipment shall be calibrated using the methods described below. Alternate methods may be used, if approved by the Owner before-hand. All test instruments shall have had a certified calibration within the last 12 months. Sensors installed in the unit at the factory with calibration certification provided need not be field calibrated.

1. All procedures used shall be fully documented on the prefunctional checklists or other suitable forms, clearly referencing the procedures followed and written documentation of initial, intermediate and final results.

2. Sensor Calibration Methods

a. All Sensors. Verify that all sensor locations are appropriate and away from causes of erratic operation. Verity that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, verify that they are reading within 0.2°F of each other for temperature and within a tolerance equal to two percent (2%) of the reading, of each other, for pressure. Tolerances for critical applications may be tighter.

b. Sensors Without Transmitters—Standard Application. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system [BAS]) is within the tolerances in the table below of the instrument-measured value. If not, install offset in BAS, calibrate or replace sensor.

c. Sensors With Transmitters—Standard Application. Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the BAS. Record all values and recalibrate controller as necessary to conform with specified control ramps, reset schedules, proportional relationship, reset relationship and P/I reaction. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system [BAS]) is within the tolerances in the table below of the instrument-measured value. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal

generator.

d. Critical Applications. For critical applications (process, manufacturing, etc.) more rigorous calibration techniques may be required for selected sensors. Describe any such methods used on an attached sheet.

3. Tolerances, Standard Applications

Sensor	Required Tolerance (+/-)	Sensor	Required Tolerance (+/-)
Cooling coil, chilled and condenser water temps	0.4 F	Flow rates, water	4% of design
		Relative humidity	4% of design
AHU wet bulb or dew point	2.0F	Combustion flue temps	5.0F
Hot water coil and boiler water temp	1.5F	CO_2 monitor	0.1 % pts
Outside air, space air, duct air temps	0.4F	CO monitor	0.01 % pts
Watthour, voltage & amperage	1% of design	Natural gas flow rate	1% of design
Pressures, air, water and gas	3% of design		
Flow rates, air	10% of design	Barometric pressure	0.1 in. of Hg

4. Valve and Damper Stroke Setup and Check:

a. EMS Readout: For all valve and damper actuator positions checked, verify the actual position against the BAS readout. Set pumps or fans to normal operating mode. Command valve or damper closed, visually verify that valve or damper is closed and adjust output zero signal as required. Command valve or damper open, verify position is full open and adjust output signal as required. Command valve or damper to a few intermediate positions. If actual valve or damper position doesn't reasonably correspond, replace actuator.

b. Closure for heating coil valves (NO): Set heating setpoint 20°F above room temperature. Observe valve open. Remove control air or power from the valve and verify that the valve stem and actuator position do not change. Restore to normal. Set heating setpoint to 20°F below room temperature. Observe the valve close.

c. Closure for cooling coil valves (NC): Set cooling setpoint 20°F above room temperature. Observe the valve close. Remove control air or power from the valve and verify that the valve stem and actuator position do not change. Restore to normal. Set cooling setpoint to 20°F below room temperature. Observe valve open.

E. Execution of Prefunctional Checklists and Startup:

1. Four (4) weeks prior to startup, the Subs and vendors schedule startup and checkout with the PM, GC and CA. The performance of the prefunctional checklists, startup and checkout are directed and executed by the Sub or vendor. When checking off prefunctional checklists, signatures may be required of other

Subs for verification of completion of their work.

2. The CA shall observe, at minimum, the procedures for each piece of primary equipment, unless there are multiple units, (in which case a sampling strategy may be used as approved by the PM). In no case will the number of units witnessed be less than four (4) on any one building, nor less than twenty percent (20%) of the total number of identical or very similar units.

3. For lower-level components of equipment, (e.g., VAV boxes, sensors, controllers), the CA shall observe a sampling of the prefunctional and start-up procedures. The sampling procedures are identified in the commissioning plan.

4. The Subs and vendors shall execute startup and provide the CA with a signed and dated copy of the completed start-up and prefunctional tests and checklists.

5. Only individuals that have direct knowledge and witnessed that a line item task on the prefunctional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

F. Deficiencies, Non-Conformance and Approval in Checklists and Startup:

1. The Subs shall clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies are provided to the CA within two days of test completion.

2. The CA reviews the report and submits either a non-compliance report or an approval form to the Sub or PM. The CA shall work with the Subs and vendors to correct and retest deficiencies or uncompleted items. The CA will involve the PM and others as necessary. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the CA as soon as outstanding items have been corrected and resubmit an updated start-up report and a Statement of Correction on the original non-compliance report. When satisfactorily completed, the CA recommends approval of the execution of the checklists and startup of each system to the PM using a standard form.

3. Items left incomplete, which later cause deficiencies or delays during functional testing may result in backcharges to the responsible party.

3.5 PHASED COMMISSIONING

A. This project will require startup and initial checkout to be executed in phases.

3.6 FUNCTIONAL PERFORMANCE TESTING

A. The general list of equipment to be commissioned is specified herein. The specific equipment and modes to be tested are found in Divisions 15 and 16.

B. The parties responsible to execute each test are listed with each test in Divisions 15 and 16.

C. Objectives and Scope: The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents, Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.

1. In general, each system shall be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions as power failure, freeze condition, low oil pressure, no flow, equipment failure, etc, shall also be tested. Specific modes required in this project are given in Divisions 15 and 16.

D. Development of Test Procedures: Before test procedures are written, the CA shall obtain all requested documentation and a current list of change orders affecting equipment or systems, including an updated points list, program code, control sequences and parameters. Using the testing parameters and requirements in Divisions 15 and 16, the CA shall develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Each Sub or vendor responsible to execute a test shall provide limited assistance to the CA in developing the procedures review (answering questions about equipment, operation, sequences, etc.)- Prior to execution, the CA shall provide a copy of the test procedures to the Sub(s) who shall review the tests for feasibility, safety, equipment and warranty protection. The CA may submit the tests to the A/E for review, if requested.

1. The CA shall review owner-contracted, factory testing or required owner acceptance tests which the CA is not responsible to oversee, including documentation format, and shall determine what further testing or format changes may be required to comply with the Specifications. Redundancy of testing shall be minimized.

2. The purpose of any given specific test is to verify and document compliance with the stated criteria of acceptance given on the test form.

3. The test procedure forms developed by the CA shall include (but not be limited to) the following information:

a. System and equipment or component name(s)
b. Equipment location and ID number
c. Unique test ID number, and reference to unique prefunctional checklist and start-up documentation ID numbers for the piece of equipment
d. Date
e. Project name
f. Participating parties
g. A copy of the specification section describing the test requirements
h. A copy of the specific sequence of operations or other specified

parameters being verified

i. Formulas used in any calculations
j. Required pre-test field measurements
k. Instructions for setting up the test.
l. Special cautions, alarm limits, etc.
m. Specific step-by-step procedures to execute the test, in a clear, sequential and repeatable format
n. Acceptance criteria of proper performance with a Yes / No check box to allow for clearly marking whether or not proper performance of each part of the test was achieved.
o. A section for comments
p. Signatures and date block for the CA

E. Test Methods:

1. Functional performance testing and verification may be achieved by manual testing, (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone dataloggers. The CA may substitute specified methods or require an additional method to be executed, other than what was specified, with the approval of the PM. This may require a change order and adjustment in charge to the Owner. The CA will determine which method is most appropriate for tests that do not have a method specified.

2. Simulated Conditions. Simulating conditions (not by an overwritten value) shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical.

3. Overwritten Values. Overwriting sensor values to simulate a condition, such as overwriting the outside air temperature reading in a control system to be something other than it really is, shall be allowed, but shall be used with caution and avoided when possible. Such testing methods often can only test a part of a system, as (he interactions and responses of other systems will be erroneous or not applicable. Simulating a condition is preferable, e.g., for the above case, by heating the outside air sensor with a hair blower rather than overwriting the value or by altering the appropriate setpoint to see the desired response. Before simulating conditions or overwriting values, sensors, transducers and devices shall be calibrated.

4. Simulated Signals. Using a signal generator which creates a simulated signal to test and calibrate transducers and DDC constants is generally recommended over using the sensor to act as the signal generator via simulated conditions or overwritten values.

5. Altering Setpoints. Rather than overwriting sensor values, and when simulating conditions is difficult, altering setpoints to test a sequence is acceptable. For example, to see the AC compressor lockout work at an outside air temperature below 55F, when the outside air temperature is above 55F, temporarily change the lockout setpoint to be 2F above the current outside air temperature.

6. Indirect Indicators. Relying on indirect indicators for responses or performance

shall be allowed only after visually and directly verifying and documenting, over the range of the tested parameters, that the indirect readings through the control system represent actual conditions and responses. Much of this verification is completed during prefunctional testing.

7. Setup. Each function and test shall be performed under conditions that simulate actual conditions as close as is practically possible. The Sub executing the test shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. necessary to execute the test according to the specified conditions. At completion of the test, the Sub shall return all affected building equipment and systems, due to these temporary modifications, to their pre-test condition.

8. Sampling. Multiple identical pieces of non-life-safety or otherwise non-critical equipment may be functionally tested using a sampling strategy. Significant application differences and significant sequence of operation differences in otherwise identical equipment invalidates their common identity. A small size or capacity difference, alone, does not constitute a difference. It is noted that no sampling by Subs is allowed in prefunctional checklist execution.

   A common sampling strategy referenced in the Project Manual as the "xx% Sampling—yy% Failure Rule" is defined by the following example.

   xx = the percent of the group of identical equipment to be included in each sample.
   yy = the percent of the sample that if failing, will require another sample to be tested.

   The example below describes a 20% Sampling—10% Failure Rule.

   a. Randomly test at least 20% (xx) of each group of identical equipment. In no case test less than three units in each group. This 20%, or three, constitute the "first sample."

   b. If 10% (yy) of the units in the first sample fail the functional performance tests, test another 20% of the group (the second sample).

   c. If 10% of the units in the second sample fail, test all remaining units in the whole group.

   d. If at any point, frequent failures are occurring and testing is becoming more troubleshooting than verification, the CA may stop the testing and require the responsible Sub to perform and document a checkout of the remaining units, prior to continuing with functionally testing the remaining units.

F. Coordination and Scheduling: The Subs shall provide sufficient notice to the CA regarding their completion schedule for the prefunctional checklists and startup of all equipment and systems. The CA will schedule functional tests through the PM, GC and affected Subs. The CA shall direct, witness and document the functional testing of all equipment and systems. The Subs shall execute the tests.

1. In general, functional testing is conducted after prefunctional testing and startup has been satisfactorily completed. The control system is sufficiently tested and approved by the CA before it is used for TAB or to verify performance of other components or systems. The air balancing and water balancing is completed and debugged before functional testing of air-related or water-related equipment or systems. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.

G. Test Equipment: Refer to Part 2 for test equipment requirements.

H. Problem Solving: The CA will recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the GC, Subs and A/E.

3.7 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

A. Documentation: The CA shall witness and document the results of all functional performance tests using the specific procedural forms developed for that purpose. Prior to testing, these forms are provided to the PM for review and approval and to the Subs for review. The CA will include the filled out forms in the O&M manuals.

B. Non-Conformance:

1. The CA will record the results of the functional test on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the PM on a standard non-compliance form.

2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CA. In such cases the deficiency and resolution will be documented on the procedure form.

3. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the CA will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so at the request of the PM.

4. As tests progress and a deficiency is identified, the CA discusses the issue with the executing contractor.

a. When there is no dispute on the deficiency and the Sub accepts responsibility to correct it:

1) The CA documents the deficiency and the Sub's response and intentions and they go on to another test or sequence. After the day's work, the CA submits the non-compliance reports to the PM for signature, if required. A copy is provided to the Sub and CA. The Sub corrects the deficiency, signs the statement of correction at the bottom of the non-compliance form certifying

that the equipment is ready to be retested and sends it back to theCA,

2) The CA reschedules the test and the test is repeated.

b. If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:

1) The deficiency shall be documented on the non-compliance form with the Sub's response and a copy given to the PM and to the Sub representative assumed to be responsible.

2) Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E. Final acceptance authority is with the Project Manager.

3) The CA documents the resolution process.

4) Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency, signs the statement of correction on the non-compliance form and provides it to the CA. The CA reschedules the test and the test is repeated until satisfactory performance is achieved.

5. Cost of Retesting:

a. The cost for the Sub to retest a prefunctional or functional test, if they are responsible for the deficiency, shall be theirs. If they are not responsible, any cost recovery for retesting costs shall be negotiated with the GC.

b. For a deficiency identified, not related to any prefunctional checklist or start-up fault, the following shall apply: The CA and PM will direct the retesting of the equipment once at no "charge" to the GC for their time. However, the CA's and PM's time for a second retest will be charged to the GC, who may choose to recover costs from the responsible Sub.

c. The time for the CA and PM to direct any retesting required because a specific prefunctional checklist or start-up test item, reported to have been successfully completed, but determined during functional testing to be faulty, will be backcharged to the GC, who may choose to recover costs from the party responsible for executing the faulty prefunctional test.

6. The Contractor shall respond in writing to the CA and PM at least as often as commissioning meetings are being scheduled concerning the status of each apparent outstanding discrepancy identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.

7. The CA retains the original non-conformance forms until the end of the project.

8. Any required retesting by any contractor shall not be considered a justified reason for a claim of delay or for a time extension by the prime contractor.

C. Failure Due to Manufacturer Defect: If ten percent (10%), or three (3), whichever is greater, of identical pieces (size alone does not constitute a difference) of equipment fail

to perform to the Contract Documents (mechanically or substantively) due to manufacturing defect, not allowing it to meet its submitted performance spec, all identical units may be considered unacceptable by the PM. In such case, the Contractor shall provide the Owner with the following:

1. Within one week of notification from the PM, the Contractor or manufacturer's representative shall examine all other identical units making a record of the findings. The findings shall be provided to the PM within two weeks of the original notice.

2. Within two weeks of the original notification, the Contractor or manufacturer shall provide a signed and dated, written explanation of the problem, cause of failures, etc. and all proposed solutions which shall include full equipment submittals. The proposed solutions shall not significantly exceed the specification requirements of the original installation.

3. The PM will determine whether a replacement of all identical units or a repair is acceptable.

4. Two (2) examples of the proposed solution will be installed by the Contractor and the PM will be allowed to test the installations for up to one week, upon which the PM will decide whether to accept the solution.

5. Upon acceptance, the Contractor and/or manufacturer shall replace or repair all identical items, at their expense and extend the warranty accordingly, if the original equipment warranty had begun. The replacement/repair work shall proceed with reasonable speed beginning within one week from when parts can be obtained.

D. Approval: The CA notes each satisfactorily demonstrated function on the test form. Formal approval of the functional test is made later after review by the CA and by the PM, if necessary. The CA recommends acceptance of each test to the PM using a standard form. The PM gives final approval on each test using the same form, providing a signed copy to the CA and the Contractor.

3.8 OPERATION AND MAINTENANCE MANUALS

A. Standard O&M Manuals:

1. The specific content and format requirements for the standard O&M manuals are detailed in Division 01. Special requirements for the controls contractor and TAB contractor are found in Division 15.

2. A/E Contribution. The A/E will include in the beginning of the O&M manuals a separate section describing the systems including:

a. The design intent narrative prepared by the A/E and provided as part of the bid documents, updated to as-built status by the A/E.

b. Simplified professionally drawn single line system diagrams on 8 Yz" x 11" or 11" x 17" sheets. These shall include chillers, water system,

condenser water system, heating system, supply air systems, exhaust systems and similar equipment. These shall show major pieces of equipment such as pumps, chillers, boilers, control valves, expansion tanks, coils, service valves, etc.

3. CA Review and Approval. Prior to substantial completion, the CA shall review the O&M manuals, documentation and redline as-builds for systems that were commissioned to verify compliance with the Specifications. The CA will communicate deficiencies in the manuals to the PM and A/E. Upon a successful review of the corrections, the CA recommends approval and acceptance of these sections of the O&M manuals to the PM and A/E. The CA also reviews each equipment warranty and verifies that all requirements to keep the warranty valid are clearly stated. This work does not supersede the A/E's review of the O&M manuals according to the A/E's contract

B. Commissioning Record in O&M Manuals:

1. The CA is responsible to compile, organize and index the following commissioning data by equipment into labeled, indexed and tabbed, three-ring binders and deliver it to the GC, to be included with the O&M manuals. Three (3) copies of the manuals will be provided. The format of the manuals shall be:

Tab I-1 Commissioning Plan
Tab 1-2 Final Commissioning Report (see (B.2) below)
Tab 01 System Type 1 (chiller system, packaged unit, boiler system, etc.)
- Sub-Tab A Design narrative and criteria, sequences, approvals for Equipment 1
- Sub-Tab B Startup plan and report, approvals, corrections, blank prefunctional checklists Colored Separator Sheets—for each equipment type (fans, pumps, chiller, etc.)
- Sub-Tab C Functional tests (completed), trending and analysis, approvals and corrections, training plan, record and approvals, blank functional test forms and a recommended recommissioning schedule.

Tab 02 System Type 2...repeat as per System 1

2. Final Report Details: The final commissioning report shall include an executive summary, list of participants and roles, brief building description, overview of commissioning and testing scope and a general description of testing and verification methods. For each piece of commissioned equipment, the report should contain the disposition of the commissioning authority regarding the adequacy of the equipment, documentation and training meeting the contract documents in the following areas: 1) Equipment meeting the equipment specifications, 2) Equipment installation, 3) Functional performance and efficiency, 4) Equipment documentation and design intent, and 5) Operator training. All outstanding non-compliance items shall be specifically listed. Recommendations for improvement to equipment or operations, future actions, commissioning process changes, etc. shall also be listed. Each non-compliance issue shall be referenced to the specific functional test, inspection, trend log, etc. where the deficiency is documented. The functional performance and efficiency section for each piece of equipment shall include a brief description of the

verification method used (manual testing, BAS trend logs, data loggers, etc.) and include observations and conclusions from the testing.

3. Other documentation will be retained by the CA.

3.9 TRAINING OF OWNER PERSONNEL

A. The GC shall be responsible for training coordination and scheduling and ultimately for ensuring that training is completed.

B. The CA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment and systems.

1. The CA shall interview the facility manager and lead engineer to determine the special needs and areas where training will be most valuable. The Owner and CA shall decide how rigorous the training should be for each piece of commissioned equipment. The CA shall communicate the results to the Subs and vendors who have training responsibilities.

2. In addition to these general requirements, the specific training requirements of Owner personnel by Subs and vendors is specified in Divisions 15 and 16.

3. Each Sub and vendor responsible for training will submit a written training plan to the CA for review and approval prior to training. The plan will cover the following elements:

   a. Equipment (included in training)

   b. Intended audience

   c. Location of training

   d. Objectives

   e. Subjects covered (description, duration of discussion, special methods, etc.

   f. Instructor for each subject

   g. Methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.)

4. For the primary HVAC equipment, the Controls Contractor shall provide a short discussion of the control of the equipment during the mechanical or electrical training conducted by others.

5. The CA develops an overall training plan and coordinates and schedules, with the CM and GC, the overall training for the commissioned systems. The CA develops criteria for determining that the training was satisfactorily completed, including attending some of the training, etc. The CA recommends approval of the training to the PM using a standard form.

6. At one of the training sessions, the CA conducts a presentation discussing the use of the blank functional test forms for re-commissioning equipment.

7. The mechanical design engineer shall at the first training session present the overall system design concept and the design concept of each equipment section. This presentation shall include a review of all systems using the simplified system schematics (one-line drawings) including chilled water systems, condenser water or heat rejection systems, heating systems, fuel oil and gas supply systems, supply air systems, exhaust system and outside air strategies.

3.10 DEFERRED TESTING

A. Unforeseen Deferred Tests: If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of checklists and functional testing may be delayed upon approval of the PM. These tests will be conducted in the same manner as the seasonal tests as soon as possible. Services of necessary parties will be negotiated.

B. Seasonal Testing: During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system's design) specified in Division 15 shall be completed as part of this contract. The CA shall coordinate this activity. Tests will be executed, documented and deficiencies corrected by the appropriate Subs, with facilities staff and the CA witnessing. Any final adjustments to the O&M manuals and as-builds due to the testing will be made.

3.11 WRITTEN WORK PRODUCTS

A. The commissioning process generates a number of written work products described in various parts of the Specifications. The Commissioning Plan—Construction Phase, lists all the formal written work products, describes briefly their contents, who is responsible to create them, their due dates, who receives and approves them and the location of the specification to create them. In summary, the written products are;

Product		Developed By
1.	Final commissioning plan	CA
2.	Meeting minutes	CA
3.	Commissioning schedules	CA with GC and PM
4.	Equipment documentation submittals	Subs
5.	Sequence clarifications	Subs and A/E as needed
5.	Prefunctional checklists	CA
6.	Startup and initial checkout plan	Subs and CA (compilation of existing documents)
7.	Startup and initial checkout forms filled out	Subs
8.	Final TAB report	TAB
9.	Issues log (deficiencies)	CA
10.	Commissioning Progress Record	CA
11.	Deficiency reports	CA
12.	Functional test forms	CA
13.	Completed functional test forms	Subs

14.	O&M manuals	Subs
15.	Commissioning record book	CA
16.	Overall training plan	CAandPM
17.	Specific training agendas	Subs
18.	Final commissioning report	CA
19.	Misc. approvals	CA

END OF COMMISSIONING REQUIREMENTS